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AIR DENSITIES FOR ATMOSPHERIC NUCLEAR TESTS AND COLUMNAR AIR MASS DATA

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ABSTRACT

A tabulation is presented of ground-zero and burst altitudes and associated dry-air and water-vapor density data for U. S. atmospheric nuclear tests. Also presented are density data for a tropical (15°N) atmosphere up to 90 kilometers. A method for computing columnar air mass between two points at different altitudes for the Pacific Proving Ground area is presented. This method can be extended to any set of spatial points within the wide limits provided and can be used for other atmospheres. Where possible, information presented is based on original data.

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SUMMARY

The Problem

Weather data for atmospheric nuclear tests are available generally in four forms: (1) as handout sheets distributed at the tests, (2) as published volumes for a particular test series, (3) as part of the Report of the Test Director, and (4) as part of a nuclear detonation report concerned with aspects other than weather data. Similarly ground-zero and burst-altitude data are scattered in various documents. Generally, this unclassified information is found only in classified reports as are most nuclear data, and thus is available to a small select group. Compilation of this information into a single unclassified list with emphasis on the veracity of the data is one main objective of this report. The second and more significant objective is to provide a means of computing the average air density between source and receiver points in the atmosphere. This capability permits evaluation of radiation exposures for any burst. In such evaluations, air density is usually multiplied by slant range, and the product is termed columnar air mass in this report.*

The Findings

Albeit most information sought was available, some shot sites were a considerable distance from the Yucca Flat weather station at the Nevada Test Site and burst times did not necessarily correspond to times at which meteorological observations were taken. Therefore, some of the weather data gathered at the Yucca Flat weather station were merely indicative of the situation when applied to ground-zero and burst altitudes. Further, for the early testing days in Nevada, some ground-zero altitudes had to be adjusted when checked against topographical maps (circa 1952) of the Nevada Test Site areas (surveyed by the Army Map Service). Errors or discrepancies were found when several documents were consulted for the same data. Data in this report are best-estimate values.

* So termed by Rand Corporation (RM-4142); also called "atmospheric depth" and "air mass in a column" by Air Force Cambridge Research Laboratories (AFCRL-62-260).

Wet (ambient) air densities varied little over the many years of testing in the Pacific Proving Ground area and had a mean value of 1.157 grams per liter at ground zero. Primarily this consistent value was due to choosing optimum conditions for detonation and to the influence of the largo heat budget of the Pacific Ocean. Wet air density at the Nevada Test Site for ground zeros, irrespective of altitude variation, had a mean value of 1.072 grams per liter with maximum excursion of +14% and -8%.

A method is presented for calculating columnar air mass as a function of altitude and results are tabulated. The average air density between any two altitudes may be found by dividing the columnar air mass between these two altitudes by the distance between them. Data given for columnar air mass over any oceanic surface up to one kilometer when compared to other model atmospheres is estimated to be reliable within 7% or less. Application of these data for cases over the USA up to ten kilometers is estimated to be reliable within 2%. The model atmosphere used was chosen to correspond to the Pacific Test area but is also not too different from that of the Nevada Site. However, at other latitudes, the variation of air density with altitude shows marked departures from the chosen model.

Recommendation

It is recommended that this tabulation be used as a convenient basic source of air density and other pertinent facts for the study of effects associated with atmospheric nuclear bursts.

CONTENTS

SECTION 1

INTRODUCTION

1.1 THE PROBLEM

An important factor associated with the study of nuclear effects is that of air density. Air density significantly influences the rate and partition of energy released from nuclear burst in the atmosphere, the energy transport by neutrons, gamma rays, x-rays, thermal radiation, and blast effects. An error in the value used for air density directly affects the accuracy of radiation- and blast-effects analyses and thus can result in errors of equal or larger magnitude in predictions based on such analyses. Accurate knowledge of ambient air densities is therefore required. Weather data from which such air densities are obtained are found with difficulty in a variety of material such as handout sheets distributed at the tests, the Reports of the Test Directors, weather reports for test series, and other reports not directly concerned with weather data. The situation is similar for ground-zero and burst altitudes. Thus, with a considerable amount of data (in many cases conflicting) in reports of varying classification, a need for carefully compiled and verified information issued as a single unclassified document has long existed.

For competent prediction of radiation and blast effects of nuclear atmospheric bursts, a rapid means of evaluation of air density is needed. However, air density is usually multiplied by slant range in effects calculations. This product is termed columnar air mass in this report.* The concept of columnar air mass applies primarily to the transmission or absorption of particulate and electromagnetic radiation emitted during an atmospheric nuclear burst. Therefore, a method for calculation of columnar air mass and a tabulation of results would facilitate predictions of nuclear burst effects.

* So termed by Rand Corporation (RM-4142); also called "atmospheric depth" and "air mass in a column" by Air Force Cambridge Research Laboratories (AFCRL-62-260).

1.2 OBJECTIVE AND SCOPE

The objective of this report is to provide accurate data on air densities, ground-zero and burst altitudes of atmospheric nuclear tests, and a capability for computing columnar air masses between selected points at different altitudes and horizontal distances over various geographical areas. A literature survey has been conducted and available data selected, compared and tabulated. Sources are referenced and in most cases provide considerably more information than is given in the limited scope of this presentation. Only U.S. atmospheric nuclear bursts are considered. Where the tabulation of basic data is incomplete, it is due to one of three reasons:

(1) non-availability of the data,
(2) security classification of all information concerning a particular shot or,
(3) inapplicability of available air density to the particular shot.

Data on which columnar air mass calculations can be based have been tabulated and a calculational method is presented. Results are given as a function of geometric altitude.

1.3 LIMITATIONS

Aside from the limited scope of presentation as described in the previous section, computation of columnar air mass is at best a hopeful endeavor. Indeed, as in many natural situations, annual, daily and moment-to-moment microscopic and macroscopic variation in the condition of the atmosphere render inaccurate all attempts at precise quantification. However, for the intended use of columnar mass, namely the study of effects associated with atmospheric nuclear bursts, the data and computational method are considered satisfactory within 7% up to one kilometer when applied over any oceanic surface. Application of these data for cases over the USA up to ten kilometers is estimated to be reliable within 2%. The model atmosphere used was chosen to correspond to the Pacific Test area but is also not too different from that of the Nevada Site. However, at other latitudes, the variation of air density with altitude shows marked departures from the chosen model.

SECTION 2

DISCUSSION OF THE DATA

2.1 TABLE 1 DATA: AIR DENSITIES FOR NUCLEAR ATMOSPHERIC BURSTS

Compilation of all available data for ground-zero and burst-height altitudes and computed dry-air and water-vapor densities appears in Table 1. This information was gathered through an extensive literature search in an effort to provide reliable data for the analysis and prediction of nuclear detonation effects. Tabulation of this information became necessary during the task of analyzing copious amounts of nuclear-weapons test data from many operations. This tabulation has been extended beyond the minimum necessary to air density determinations since a compendium of this sort may easily have uses other than originally intended.

Operations and the nuclear tests composing each operation are listed in chronological order with associated times of detonation in Greenwich Civil Time (GCT). To translate GCT to Pacific Proving Ground (PPG) local time, add 12 hours. Nevada Test Site (NTS) local time may be found by subtracting 8 hours from GCT. However, it should be noted that for shots in Nevada, Daylight Saving Time was in effect for tests occurring between the beginning of May and October.

For all detonations in Nevada, the site is listed as NTS. For detonations in the Pacific, the atoll on, near, or over which the test took place is listed as the site. For the tower shots, burst heights are not exact. Elevations listed are for nominal tower heights and do not include the additional height from the center of mass of the device to the cab floor. In addition, for the Trinity shot the ground zero altitude measurement was actually 800 yards from true ground zero and was taken from an altimeter calibrated at Kirtland, New Mexico, as part of the 100-ton pre-nuclear test shot. However, it is believed that to make additional corrections would be of little consequence for this tabulation.

References 1-18 are the sources used for Table 1 weather data. In general, pressure measurements are probably good to one millibar (10^3 dynes/cm^2) and temperatures to one degree centigrade. Consequently,

density data are assumed accurate to within 1/2%. In Operation Sandstone, burst-altitude weather data for Shot X-ray were taken from Ref. 3 and, for the rest of the Operation, from Ref. 4. In most cases, weather data were taken a few minutes to a few hours before or after the particular shot. Furthermore, in many cases, data were taken at various altitudes other than the exact burst heights. Therefore, in those cases, a linear interpolation was made to estimate weather data corresponding to a specific shot time and burst altitude.

No data for air-density computations similar to those obtained at the preceding operations were available for Operation Dominic. However, some data were taken in the upper atmosphere by a rocket-launched free-falling-sphere method (see Ref. 19). Upon examination, measurements were found to be similar to the values of air density vs altitude given in Ref. 20 (presented in Table 2).

All data computed in Table 1 are based on constants and equations found in the Smithsonian Meteorological Tables.[21] Dew-point measurements are converted to vapor-pressure using the tabulation, 'Saturated Vapor Pressure Over Water' (pg. 351), even when the dew-point is below freezing temperature. Detailed explanations for this procedure can be found on pg. 358, Handbook of Meteorology,[22] and on pg. 348 in the Smithsonian Tables. When the dew-point was unavailable, vapor pressure was found as a function of air temperature and then multiplied by the relative humidity to obtain the values used. Vapor density was found by dividing vapor pressure by air temperature and then multiplying by the appropriate gas constant. Dry air density was found by dividing air pressure minus vapor pressure by air temperature and then multiplying by the appropriate gas constant. Wet air density (ambient air density) was found by summing vapor density and dry air density.

2.2 TABLE 2 DATA: COLUMNAR AIR MASS AS A FUNCTION OF GEOMETRIC ALTITUDE

Input data of Table 2 listed in column 2 were taken from Ref. 20 and represent a model tropical atmosphere up to 90 kilometers at 15° North latitude. This model atmosphere was chosen for three reasons:

(1) it corresponds to PPG atmosphere for tests at which data were taken,
(2) it is similar to the NTS (U.S.) atmosphere with a minimum of correction, and
(3) in comparison to other model atmospheres in Ref. 20, it seems to be better suited for naval applications.

Vertical columnar air mass, column 3 of Table 2, was found by point-to-point numerical integration using the equation:

$$\int_{H_1}^{H_2} \rho \Delta y = (\rho_1 - \rho_2)\ (H_2 - H_1)/\log_e\ (\rho_1/\rho_2) \qquad (1)$$

where ρ_1 and ρ_2 are the model air densities at their respective geometric heights, H_1 and H_2. If we assume

$$\rho = \rho_o \quad ^{-by}$$

then

$$\int_{H_1}^{H_2} \rho \Delta y = \int_{H_1}^{H_2} \rho_o e^{-by}\ dy$$

$$= \frac{1}{b} \left[\rho_o e^{-bH_1} - \rho_o e^{-bH_2}\right]$$

$$= (\rho_1 - \rho_2)/b$$

but

$$(H_2 - H_1)b = \log_e\ (\rho_1/\rho_2)$$

which, when substituted in the preceding equation, gives us Eq. 1. This form of integration was used (between consecutive kilometers) because of the generally semi-logarithmic dependence of air density on geometric altitude. Remaining columnar air mass (columnar air mass above a given altitude), column 4 of Table 2, was computed simply by subtracting values of column 3 (rounded off numbers appear in the table) from the value 1037.898876000 g/cm^2, which represents a total columnar air mass, M_∞, applicable to an infinite geometric altitude. An estimate of this "total" was derived by requiring that the ratio of air density to remaining columnar air mass for the last two entries (89 and 90 km) be equal, i.e.

$$\frac{RM_{89}}{\rho_{89}} = \frac{RM_{90}}{\rho_{90}}$$

thus the equations:

$$M_{\infty} - M_{89} = RM_{89}$$

$$M_{\infty} - M_{90} = RM_{90}$$

may be solved for M_{∞} (see next section for definitions). The "total" columnar air mass value thus is an extrapolated value based on the semi-logarithmic nature of the function integrated. The use of this "total" in the computations preserves the shape of the 'Remaining Columnar Air Mass' curve; i.e., in the region of 90 km and beyond the curve continues with a constant slope.

Air density vs geometric altitude is plotted in Fig. 1. Remaining vertical columnar air mass vs geometric altitude is plotted in Fig. 2.

2.3 COMPUTATION OF COLUMNAR AIR MASS

The method for computing columnar air mass is derived in the following paragraphs. The equation for columnar air mass (M) between two points separated in altitude and horizontal distance can be expressed (in g/cm^2) as:

$$M = \frac{RM_1 - RM_2}{H_2 - H_1} \times \frac{\rho_a}{\rho_m} \times SR \tag{2}$$

where

RM_1 = remaining columnar air mass (g/cm^2) above the altitude H_1 (km)

RM_2 = remaining columnar air mass (g/cm^2) above the altitude H_2 (km)

ρ_a = ambient air density (g/l) at any altitude between H_1 and H_2

ρ_m = model atmosphere air density (g/l) at the same altitude as ρ_a

SR = slant range (km)

At other than integral altitudes linear interpolation between values in the table is sufficiently accurate (variation < .13% between 0 an 1 km). Equation 2 and subsequent equations could also be expressed in terms of the difference in columnar air mass, i.e. $M_1 - M_2$, but this would necessitate an inordinate number of digits in these terms (to accomplish the same task) particularly at high altitudes.

The difference:

$$RM_1 - RM_2 \tag{3}$$

represents the vertical columnar air mass between two altitudes, H_1 and H_2.

The function:

$$\frac{RM_1 - RM_2}{H_2 - H_1} \tag{4}$$

is the average vertical columnar air mass per kilometer of altitude. In the special case where $H_2 = H_1$ for a horizontal path M can be expressed as:

$$M = \rho_H \times \frac{\rho_a}{\rho_m} \times SR \times 10^2 \tag{2a}$$

in the units previously given. The ratio ρ_a/ρ_m corrects the value from that of the model atmosphere to that of the ambient atmosphere. Use of ambient air density data in the neighborhood of H_1 and H_2 is the desirable procedure. If such data are not available a close approximation to the actual columnar air mass may be obtained by substituting for $\frac{\rho_a}{\rho_m}$ the ratio $\frac{\rho_{sl}}{\rho_{msl}}$,

where ρ_{sl} = ambient (wet) air density at sea level

ρ_{msl} = model atmosphere air density at sea level (1.16655 in Table 2

If ρ_{sl} is not known, the following values are recommended for the ratio

of ρ_{sl} to ρ_{msl}:

Area/Season	ρ_{sl}/ρ_{msl}
USA (if season/location not specified)	1.05011
30° N July	.99369
30° N Jan	1.05678
45° N July	1.02177
45° N Jan	1.11524
60° N July	1.04566
60° N Jan	1.17637
75° N July	1.08404
75° N Jan	1.21446

No model-atmosphere data are available for the Southern Hemisphere. However, it is estimated (based on latitude pressure dependence) that applicable values of the ρ_{sl}/ρ_{msl} ratio for the Northern Hemisphere could be used, i.e., 30° N July for 30° S Jan.

A correction for the curvature of the earth is ignored. Its inclusion changes the slant range less than one percent with 1500 km and introduces an error of less then one percent in the columnar air mass within 100 km horizontal range. However, the error between the 'flat-earth' and 'round-earth' case increased rapidly for horizontal (ground) ranges greater than 100 km. Other useful manipulations are:

$$\bar{\rho} = \frac{RM_1 - RM_2}{H_2 - H_1} \times \frac{\rho_a}{\rho_m} \times 10^{-2} \text{ g/l} \tag{5}$$

and

$$Rel = \frac{RM_1 - RM_2}{H_2 - H_1} \times \frac{\rho_a}{\rho_m} \times \frac{10^{-2}}{\rho_{std}} \tag{6}$$

where $\bar{\rho}$ = average ambient vertical air density (g/l)

ρ_{std} = any arbitrarily selected standard for sea level air density (two standards frequently employed are 1.2923 g/l, STP and 1.2255 g/l, density at 1 atmosphere and 15°C)

$$\text{Rel} = \frac{\bar{\rho}}{\rho_{std}} = \text{average relative air density (a dimensionless number)}$$

The following examples illustrate the use of Table 2 or Figs. 1 and 2:

Example 1: What is the columnar air mass (Eq. 2) between two points at 1 km and 0 km altitudes, separated by 1 km horizontal ground distance, where the ambient sea level air density is 1.150 g/l? From Table 2; RM_2 is 9.26428+2*, RM_1 is 1.03790+3*, and ρ_{msl} is 1.16655. Slant range, SR, is 1.41421, H_1 is 0, H_2 is 1, and ρ_{sl} is 1.150. Thus, the columnar air mass is:

$$M = \frac{1.03790\text{x}10^3 - 9.26428\text{x}10^2}{1 - 0} \text{ x } \frac{1.150}{1.16655} \text{ x } 1.41421$$

or

$$M = 155.408 \text{ g/cm}^2$$

Example 2: Using the conditions in Ex. 1, what is the average relative air density (Eq. 6) where the standard air density, ρ_{std}, is 1.2923 g/l? The relative air density is:

$$\text{Rel} = \frac{1.03790\text{x}10^3 - 9.26428\text{x}10^2}{1 - 0} \text{ x } \frac{1.150}{1.16655} \text{ x } \frac{10^{-2}}{1.2923} = 0.85035$$

* +2, +3, etc. stand for powers of 10 in Table 2

SECTION 3

CONCLUSIONS

The data presented in Table 1 are the most reliable that are available at NRDL. In general, Table 1 pressure measurements are probably good to one millibar and temperatures to one degree centigrade. Consequently, density data are assumed accurate to within 1/2%.

Columnar air mass computations based on data in Table 2 and the method given in the text generate values sufficiently accurate for use in the study of nuclear weapons effects. Comparison of the air density values in Table 2 with other model atmospheres in Ref. 20 indicates that, when the actual sea-level air density is known, the computation of columnar air mass is valid (within 7% or less) over oceanic surfaces other than the Pacific Proving Ground area at low altitudes (~ 1 km). At altitudes higher than 1 km, other model atmospheres vary considerably from the model chosen; thus the air densities of Table 2 are not in close agreement. Computations for the USA appear to be good to 2% up to 10 km. However, for extreme altitude differences, error in columnar air mass due to curvature tends to be minimized by the averaging effect of columnar mass tabulations. All columnar air mass computations should be confined to 100 km horizontal (ground) range to achieve 1% computational accuracy. Further discussion of accuracy may be found in Sec. 1.3.

In conclusion, this report provides a useful source of basic data on pertinent air densities, altitude and columnar air masses for the study of effects of atmospheric nuclear bursts.

REFERENCES

1. LA-1027, Trinity, Defense Atomic Support Agency, Vol. 24, Appendix 55-71, (Classified)

2. XRD-209, Report of the Technical Director, Operation Crossroads, Defense Atomic Support Agency, Vol. 1, (Classified)

3. Classified Scientific Meteorological Information Operation Sandstone, Defense Atomic Support Agency, SS-35

4. Unpublished LASL-AEC-OFFICIAL Weather Files, Operation Sandstone, Los Alamos Scientific Laboratory

5. Reines, F., Handbook for Operation Ranger and A Summary of Test Results (U), Defense Atomic Support Agency, WT-202, Vol. 2, (Classified)

6. Operation Greenhouse Meteorological Data, Defense Atomic Support Agency, WT-49, Mar-May 1950

7. Karstens, E. H., Air Weather Service Participation in Operation Buster, Defense Atomic Support Agency, WT-342, Dec. 1951

8. Karstens, E. H., Air Weather Service Participation in Operation Jangle, Defense Atomic Support Agency, WT-361, Dec. 1951

9. Karstens, E. H., Dyer, C. L., Air Weather Service Participation in Operation Tumbler-Snapper, Defense Atomic Support Agency, WT-508, Jan. 1953

10. Moulton, J. F., Jr., Nuclear Weapons Blast Phenomena, Defense Atomic Support Agency, DASA-1200, Vol. 1, 1960, (Classified)

11. Morgan, D. N., et. al., Air Weather Service Participation in Operation Upshot-Knothole, Defense Atomic Support Agency, WT-703, July 1953

12. Unpublished LASL-AEC-OFFICIAL Weather Files, Operation Castle, Los Alamos Scientific Laboratory

13. Unpublished LASL-AEC OFFICIAL Weather Files, Operation Teapot, Los Alamos Scientific Laboratory

14. Unpublished LASL-AEC OFFICIAL Weather Files, Operation Redwing, Los Alamos Scientific Laboratory

15. Unpublished LASL-AEC OFFICIAL Weather Files, Operation Plumbob, Los Alamos Scientific Laboratory

16. Meteorolcgical Report, Operation Hardtack I, Defense Atomic Support Agency, I JTFMC TP-8, Vol. 1-5, 1958

17. Unpublished LASL-AEC OFFICIAL Weather Files, Operation Hardtack II, Los Alamos Scientific Laboratory

18. Operation Nougat and Sunbeam, DASA Organizational, Operational Finding, and Logistic Summary (U), Defense Atomic Support Agency, WT-2293, Feb. 1964, (Classified)

19. Champion, K. S. W., Faire, A. C., Atmospheric Properties (U), Defense Atomic Support Agency, Air Force Cambridge Research Laboratories, L. G. Hanscom Field, Bedford, Mass., WT-2040, March 1965 (Classified)

20. Valley, S. S., (Editor), Handbook of Geophysics and Space Environments, Air Force Cambridge Research Laboratories, McGraw-Hill Books Co., Inc., April 1965

21. List, R. J., Smithsonian Meteorological Tables, Published by the Smithsonian Institution, 1958

22. Berry, F. A., Jr., et. al., Handbook of Meteorology, McGraw-Hill Book Co., Inc., 1945

Operation	Name	Date (GCT)	Time (GCT)	Location of Shot	Ground Zero Alt MSL (feet)	Burst Alt MSL (feet)	Height of Burst (feet)	Type of Burst	Air Pressure Ground Zero (mb)	Air Pressure Burst Height (mb)	Air Temperature Ground Zero (°C)	Air Temperature Burst Height (°C)
Trinity		16/7/45	1230	Alamogordo New Mexico	4979	5079	100	Tower	851.7		20	
Crossroads	Able	30/6/46	2201	Bikini	0	518	518	Air	1012.2		30	
Sandstone	X-ray	14/4/48	1817	Eniwetok	0	200	200	Tower	1011.8	1009	27.2	27
	Yoke	30/4/48	1809	"	0	200	200	"	1010.5	1003.7	27.0	26.5
	Zebra	14/5/48	1804	"	0	200	200	"	1008.0	1001.3	27.0	26.0
Ranger	Able	27/1/51	1345	NTS	3140	4200	1060	Air	903	868	- 2.0	6.1
	Baker	28/1/51	1352	"	3140	4220	1080	"	899	864	- 2.8	7.4
	Easy	1/2/51	1347	"	3140	4220	1080	"	919	879	-11.5	- 5.1
	Baker-2	2/2/51	1349	"	3140	4240	1100	"	920	881	- 9.2	- 2.6
	Fox	6/2/51	1347	"	3140	4575	1435	"	909	862	- 2.0	7.5
Greenhouse	Dog	7/4/51	1834	Eniwetok	0	300	300	Tower	1012.2	1002.2	26.1	26.1
	Easy	20/4/51	1827	"	0	300	300	"	1010.2	1000.2	26.7	26.7
	George	8/5/51	2130	"	0	200	200	"	1007.1	1000.4	27.2	27.2
	Item	24/5/51	1817	"	0	200	200	"	1011.9	1005.2	26.7	26.7
Buster-Jangle	Able	22/10/51	1400	NTS	4169	4269	100	Tower	874	870	5.8	5.9
	Baker	28/10/51	1520	"	4193	5311	1118	Air	877	840	11.4	9.8
	Charlie	30/10/51	1500	"	4193	5325	1132	"	872	835	5.3	11.2
	Dog	1/11/51	1530	"	4193	5610	1417	"	876	832	15.5	12.0
	Easy	5/11/51	1630	"	4224	5538	1314	"	878	838	11.3	8.4
	Sugar	19/11/51	1700	"	4213	4217	4	Surface	871.5		1.0	
Tumbler-Snapper	Able	1/4/52	1700	NTS	3078	3871	793	Air	914	888.5	14.44	13.61
	Baker	15/4/52	1730	"	4193	5302	1109	"	878	842	11.56	8.89
	Charlie	22/4/52	1730	"	4193	7640	3447	"	873	770	18.94	7.39
	Dog	1/5/52	1630	"	4193	5233	1040	"	877	845	17.11	15.0
	Easy	7/5/52	1215	"	4240	4540	300	Tower	866	856	15.83	17.67
	Fox	25/5/52	1200	"	4310	4610	300	"	868	858	13.94	19.44
	George	1/6/52	1155	"	4027	4327	300	"	872	862	11.44	14.11
	How	5/6/52	1155	"	4493	4793	300	"	863	854	17.78	20.39
Ivy	Mike	31/10/52	1915	Eniwetok	0	20	20	Tower	1011		29.4	
	King	15/11/52	2330	"	0	1480	1480	Air	1011	962	28.0	25.4
Upshot-Knothole	Annie	17/3/53	1320	NTS	4025	4325	300	Tower	876	866	2.7	7.9
	Nancy	24/3/53	1310	"	4308	4608	300	"	870	860	9.9	13.3
	Ruth	31/3/53	1300	"	4164	4464	300	"	873	863	4.4	8.2

TABLE 1
Air Densities for Nuclear
Atmospheric Bursts

(* terms defined at end of Table)

Type of Burst	Air Pressure Ground Zero (mb)	Air Pressure Burst Height (mb)	Air Temperature Ground Zero (°C)	Air Temperature Burst Height (°C)	Dew Point * Ground Zero (°C)	Dew Point * Burst Height (°C)	Relative Humidity * Ground Zero (%)	Relative Humidity * Burst Height (%)	Vapor Pressure * Ground Zero (mb)	Vapor Pressure * Burst Height (mb)	Vapor Density * Ground Zero (g/l)	Vapor Density * Burst Height (g/l)
Tower	851.7		20		16.1				18.3		.0135	
Air	1012.2		30				68		29.3		.0209	
Tower	1011.8	1009	27.2	27	24.6			81	30 9	28.9	.0223	.0209
"	1010.5	1003.7	27.0	26.5			76.5	75	27.3	26.0	.0197	.0188
"	1008.0	1001.3	27.0	26.0			81	80	28.9	26.9	.0209	.0195
Air	903	868	- 2.0	6.1			73	55	3.85	5.18	.00306	.00402
"	899	864	- 2.8	7.4			87	57	4.33	5.87	.00347	.00453
"	919	879	-11.5	- 5.1			89	65	2.26	2.72	.00187	.00220
"	920	881	- 9.2	- 2.6			79	61	2.43	3.08	.00199	.00247
"	909	862	- 2.0	7.5			85	53	4.48	5.49	.00358	.00424
Tower	1012.2	1002.2	26.1	26.1	21.7	21.7			26.0	26.0	.0188	.0188
"	1010.2	1000.2	26.7	26.7	21.1	21.1			25.0	25.0	.0181	.0181
"	1007.1	1000.4	27.2	27.2	25.0	25.0			31.7	31.7	.0229	.0229
"	1011.9	1005.2	26.7	26.7	22.8	22.8			27.7	27.7	.0200	.0200
Tower	874	870	5.8	5.9			22	23	2.03	2.13	.00158	.00165
Air	877	840	11.4	9.8			28	27	3.77	3.27	.00287	.00250
"	872	835	5.3	11.2			14	14	1.25	1.86	.000973	.00142
"	876	832	15.5	12.0			43	58	7.57	8.13	.00568	.00618
"	878	838	11.3	8.4			17	18	2.28	1.98	.00174	.00152
Surface	871.5		1.0		- 9.5				2.98		.00236	
Air	914	888.5	14.44	13.61			28	30	4.56	4.67	.00344	.00353
"	878	842	11.56	8.89			30	30	4.10	3.42	.00312	.00263
"	873	770	18.94	7.39			30	47	6.55	4.84	.00486	.00374
"	877	845	17.11	15.0			47	50	9.16	8.52	.00684	00641
Tower	868	850	15.83	17.57			40	37	5.18	7.49	.00240	.00558
"	868	858	13.94	19.44			41	41	6.51	9.23	.00491	.00684
"	872	862	11.44	14.11			48	50	6.47	8.04	.00493	.00606
"	863	854	17.78	20.39			45	50	9.27	11.98	.00603	.00884
Tower	1011		29.4		23.8				29.5		.0911	
Air	1011	962	28.0	25.4	23.5	22.2			28.9	26.6	.0208	.0195
Tower	876	866	2.7	7.9	- 8.5	- 5.4			3.22	4.09	.00253	.00315
"	870	860	9.9	13.3	- 3.6	- 3.2			4.68	4.83	.00358	.00365
"	873	863	4.4	8.3	- 5.3	- 7.4			4.12	3.51	.00322	.00270

(* terms defined at end of Table)

ive Humidity *	Vapor Pressure *		Vapor Density *		Dry Air Density *		Wet Air Density *		
Burst Height (%)	Ground Zero (mb)	Burst Height (mb)	Ground Zero (g/l)	Burst Height (g/l)	Ground Zero (g/l)	Burst Height (g/l)	Ground Zero (g/l)	Burst Height (g/l)	References
	18.3		.0135		.990		1.004		1
	29.3		.0209		1.130		1.150		2
81	30.9	28.9	.0223	.0209	1.138	1.138	1.160	1.158	3, 4
75	27.3	26.0	.0197	.0188	1.141	1.137	1.161	1.155	4
80	28.9	26.9	.0209	.0195	1.136	1.135	1.157	1.154	4
55	3.85	5.18	.00306	.00402	1.148	1.076	1.15?	1.080	5
57	4.33	5.87	.00347	.00453	1.153	1.066	1.156	1.070	5
65	2.26	2.72	.00187	.00220	1.221	1.139	1.222	1.141	5
61	2.43	3.08	.00199	.00247	1.211	1.130	1.213	1.133	5
53	4.48	5.49	.00358	.00424	1.162	1.063	1.166	1.067	5
	26.0	26.0	.0188	.0188	1.148	1.136	1:167	1.155	6
	25.0	25.0	.0181	.0181	1.145	1.133	1.163	1.151	6
	31.7	31.7	.0229	.0229	1.131	1.124	1.154	1.146	6
	27.7	27.7	.0200	.0200	1.143	1.136	1.163	1.156	6
23	2.03	2.13	.00158	.00165	1.089	1.083	1.091	1.085	7
27	3.77	3.27	.00287	.00250	1.069	1.030	1.072	1.033	7
14	1.25	1.86	.000973	.00142	1.089	1.021	1.090	1.022	7
58	7.57	8.13	.00568	.00618	1.048	1.007	1.054	1.013	7
18	2.28	1.98	.00174	.00152	1.073	1.034	1.074	1.036	7
	2.98		.00236		1.104		1.106		8
30	4.56	4.67	.00344	.00353	1.102	1.074	1.105	1.077	9
30	4.10	3.42	.00312	.00263	1.069	1.036	1.072	1.038	9
47	6.59	4.84	.00486	.00374	1.035	.950	1.040	.954	9
50	9.16	8.52	.00684	.00641	1.042	1.011	1.048	1.018	9
37	3.18	7.49	.00240	.00558	1.049	1.019	1.044	1.024	9
41	6.51	9.23	.00491	.00684	1.045	1.011	1.050	1.017	9
50	6.47	8.04	.00493	.00606	1.060	1.036	1.064	1.042	9
50	9.17	11.98	.00683	.00884	1.022	.999	1.029	1.008	9
	29.5		.0211		1.130		1.151		10
	28.9	26.8	.0208	.0195	1.136	1.091	1.157	1.111	10
	3.22	4.09	.00253	.00315	1.102	1.068	1.105	1.072	11
	4.68	4.83	.00358	.00365	1.065	1.040	1.069	1.044	11
	4.12	3.51	.00322	.00270	1.091	1.064	1.094	1.067	11

3

Operation	Name	Date (OCT)	Time (OCT)	Location of Shot	Ground Zero Alt MSL (feet)	Burst Alt MSL (feet)	Height of Burst (feet)	Type of Burst	Air Pressure Ground Zero (mb)	Air Pressure Burst Height (mb)	Air Grou Zero
Upshot-Knothole (Cont.)	Dixie	6/4/53	1530	NTS	4191	10211	6020	Air	861	686	15.5
	Ray	11/4/53	1245	"	4240	4340	100	Tower	869	866	- .3
	Badger	18/4/53	1235	"	4492	4792	300	"	862	852	7.7
	Simon	25/4/53	1230	"	4238	4538	300	"	870	860	11.7
	Encore	8/5/53	1530	"	3078	5503	2425	Air	900	825	16.7
	Harry	19/5/53	1205	"	4009	4309	300	Tower	874	864	14.3
	Grable	25/5/53	1530	"	3078	3606	524	Gun	901	884	14.8
	Climax	4/6/53	1115	"	4210	5544	1334	Air	867	824	13.3
Castle	Bravo	28/2/54	1845	Bikini	10.0	17.0	7	Surface	1006.1		26.7
	Romeo	26/3/54	1830	"	7.2	14.2	7	Barge	1012.4		26.7
	Koon	6/4/54	1820	"	8.0	21.6	13.6	Surface	1009.7		27.2
	Union	25/4/54	1810	"	5.8	12.8	7	Barge	1007.4		27.2
	Yankee	4/5/54	1810	"	6.6	13.6	7	"	1010.8		27.1
	Nectar	13/5/54	1820	Eniwetok	7.2	14.2	7	"	1006.4		26.7
Teapot	Wasp	18/2/55	2000	NTS	4195	4957	762	Air	870	845	- 3.5
	Moth	22/2/55	1345	"	4026	4326	300	Tower	879	870	- 7.7
	Tesla	1/3/55	1330	"	4201	4501	300	"	876	866	- 4.2
	Turk	7/3/55	1320	"	4491	4991	500	"	870	854	5.0
	Hornet	12/3/55	1320	"	4007	4307	300	"	881	872	- 1.0
	Bee	22/3/55	1305	"	4245	4745	500	"	875	860	1.0
	Apple-1	29/3/55	1255	"	4309	4809	500	Tower	867	852	8.0
	Wasp'	29/3/55	1800	"	4195	4935	740	Air	871	849	13.4
	HA	6/4/55	1800	"	4030	36,620	32,590	"	883	222	10.2
	Post	9/4/55	1230	"	4236	4536	300	Tower	875	865	4.2
	Met	15/4/55	1915	"	3078	3478	400	"			
	Apple-2	5/5/55	1210	"	4236	4736	500	"	871	855	9.6
	Zucchini	15/5/55	1200	"	4245	4745	500	"	866	852	3.0
Redwing	Lacrosse	4/5/56	1825	Eniwetok	0	17	17	Surface	1008.5		27.2
	Cherokee	20/5/56	1751	Bikini	0	4320	4320	Air	1009.0	870	27.2
	Zuni	27/5/56	1756	"	0	9	9	Surface	1010.5		27.2
	Erie	30/5/56	1815	Eniwetok	0	300	300	Tower	1009.1	1003	26.8
	Seminole	6/6/56	0055	"	0	4.5	4.5	Surface	1010.5		30.5
	Flathead	11/6/56	1826	Bikini	0	15	15	Barge	1012.9		27.8
	Blackfoot	11/6/56	1826	Eniwetok	0	200	200	Tower	1012.5	1006	27.3
	Osage	16/6/56	0114	"	0	680	680	Air	1008.5		29.9
	Dakota	25/6/56	1806	Bikini	0	0	0	Barge	1009.1		27.8
	Apache	8/7/56	1806	Eniwetok	0	0	0	"	1010.5		26.8
	Navajo	10/7/56	1756	Bikini	0	15	15	"	1010.2		27.3
	Tewa	20/7/56	1746	"	0	15	15	"	1009.3		27.8
	Huron	21/7/56	1816	Eniwetok	0	1[illegible]	15	"	1007.8		27.4

TABLE 1 (Cont.)

(* terms defined at end of Table

Height of Burst (feet)	Type of Burst	Air Pressure Ground Zero (mb)	Air Pressure Burst Height (mb)	Air Temperature Ground Zero (°C)	Air Temperature Burst Height (°C)	Dew Point* Ground Zero (°C)	Dew Point* Burst Height (°C)	Relative Humidity* Ground Zero (%)	Relative Humidity* Burst Height (%)	Vapor Pressure* Ground Zero (mb)	Vapor Pressure* Burst Height (mb)	Vapor Density* Ground Zero (g/1)	Vapor Density* Burst Height (g/1)
380	Air	861	686	15.5	- .6	- 4.1	-13.7			4.51	2.13	.00338	.0016
100	Tower	869	866	- .3	- .1	-11.3	-11.7			2.58	2.50	.00205	.0019
300	"	862	852	7.7	7.2	- 3.9	- 4.1			4.58	4.51	.00353	.0034
300	"	870	860	11.7	15.3	- 7.3	- 4.7			3.53	4.31	.00268	.0032
425	Air	900	825	16.7	8.0	- 7.0	-12.5			3.62	2.34	.00270	.0018
300	Tower	874	864	14.3	18.3	- .6	4.5			5.85	8.42	.00441	.0062
394	Gun	901	864	14.8	13.1	- 3.8	- 7.2			4.61	3.56	.00347	.0026
134	Air	867	894	13.3	12.2	- 3.9	- 1.5			4.58	5.47	.00346	.0041
7	Surface	1006.1		26.7		22.2				26.8		.0194	
7	Barge	1012.4		26.7		22.2				26.8		.0194	
13.6	Surface	1009.7		27.2		23.9				29.7		.0214	
7	Barge	1007.4		27.2		24.4				30.6		.0221	
7	"	1010.8		27.1		23.9				29.7		.0214	
7	"	1006.4		26.7		23.9				29.7		.0214	
762	Air	870	845	- 3.5	- 6.4	-16.6	-19.0			1.67	1.37	.00134	.0011
300	Tower	879	870	- 7.7	- 4.4	-15.1	-13.0			1.90	2.25	.00155	.0018
300	"	876	866	- 4.2	- 1.1	-15.2	-14.5			1.88	1.99	.00152	.0015
500	"	870	854	5.0	5.9	- 9.8	- 8.5			2.91	3.22	.00227	.0025
300	"	881	872	- 1.0	2.5	- 7.6	- 4.1			3.45	4.51	.00275	.0035
500	"	875	860	1.0	4.5	-14.1	-13.5			2.06	2.16	.00163	.0016
500	Tower	867	852	8.0	9.3	- 1.4	- 0.9			5.51	5.72	.00425	.0043
740	Air	871	849	13.4	12.6	- 1.5	1.5			5.47	5.47	.00414	.0041
2,590	"	883	222	10.2	-47.8	- 8.0				3.35		.00256	
300	Tower	875	865	4.2	8.7	- 9.8	- 5.7			2.91	4.00	.00227	.0030
400	"												
500	"	871	855	9.6	14.2	- 5.2	- 3.0			4.15	4.90	.00318	.0036
500	"	866	852	3.0	2.1	- 8.5	- 8.9			3.22	3.12	.00253	.0024
17	Surface	1008.5		27.2		25.0				31.7		.0229	
320	Air	1009.0	870	27.2	15.5	22.8	10.8			27.7	12.9	.0200	.0096
9	Surface	1010.5		27.2		24.4				30.6		.0221	
300	Tower	1009.1	1003	26.8	26.6	23.1	22.0			28.3	26.4	.0204	.0191
4.5	Surface	1010.5		30.5		24.7				31.1		.0222	
15	Barge	1012.9		27.8		24.4				30.6		.0220	
200	Tower	1012.5	1006	27.3	26.6	24.3	23.8			30.4	29.5	.0219	.0213
680	Air	1008.5		29.9		24.8				31.3		.0224	
0	Barge	1009.1		27.8		23.9				29.7		.0214	
0	"	1010.5		26.8		23.8				29.5		.0213	
15	"	1010.2		27.3		23.3				28.6		.0206	
15	"	1009.3		27.8		25.0				31.7		.0228	
15	"	1007.8		27.4		24.6				30.9		.0223	

(* terms defined at end of Table)

Relative Humidity* Ground Zero (%)	Relative Humidity* Burst Height (%)	Vapor Pressure* Ground Zero (mb)	Vapor Pressure* Burst Height (mb)	Vapor Density* Ground Zero (g/l)	Vapor Density* Burst Height (g/l)	Dry Air Density* Ground Zero (g/l)	Dry Air Density* Burst Height (g/l)	Wet Air Density* Ground Zero (g/l)	Wet Air Density* Burst Height (g/l)	References
		4.51	2.13	.00338	.00169	1.034	.874	1.037	.876	11
		2.58	2.50	.00205	.00198	1.106	1.102	1.108	1.104	11
		4.58	4.51	.00353	.00348	1.064	1.053	1.067	1.057	11
		3.53	4.31	.00268	.00324	1.060	1.033	1.062	1.037	11
		3.62	2.34	.00270	.00180	1.077	1.019	1.080	1.021	11
		5.85	8.42	.00441	.00626	1.052	1.023	1.057	1.029	11
		4.61	3.56	.00347	.00269	1.084	1.072	1.088	1.074	11
		4.58	5.47	.00346	.00415	1.049	.999	1.052	1.003	11
		26.8		.0194		1.138		1.157		12
		26.8		.0194		1.145		1.164		12
		29.7		.0214		1.137		1.158		12
		30.6		.0221		1.133		1.155		12
		29.7		.0214		1.138		1.160		12
		29.7		.0214		1.133		1.155		12
		1.67	1.37	.00134	.00111	1.122	1.102	1.123	1.103	13
		1.90	2.25	.00155	.00181	1.151	1.125	1.153	1.127	13
		1.88	1.99	.00152	.00158	1.133	1.106	1.135	1.108	13
		2.91	3.22	.00227	.00250	1.086	1.062	1.088	1.065	13
		3.45	4.51	.00275	.00355	1.123	1.096	1.126	1.100	13
		2.06	2.16	.00163	.00169	1.109	1.076	1.111	1.078	13
		5.51	5.72	.00425	.00439	1.067	1.044	1.072	1.048	13
		5.47	5.47	.00414	.00415	1.052	1.028	1.056	1.033	13
		3.35		.00256		1.082	.343	1.084	.343	13
		2.91	4.00	.00227	.00308	1.095	1.064	1.098	1.067	13
		4.15	4.90	.00318	.00369	1.068	1.031	1.071	1.034	13
		3.22	3.12	.00253	.00246	1.088	1.074	1.091	1.077	13
		31.7		.0229		1.133		1.156		14
		27.7	12.9	.0200	.00968	1.138	1.034	1.158	1.044	14
		30.6		.0221		1.137		1.159		14
		29.3	26.4	.0204	.0191	1.139	1.135	1.160	1.154	14
		31.1		.0222		1.124		1.146		14
		30.6		.0220		1.137		1.159		14
		30.4	29.5	.0219	.0213	1.139	1.135	1.161	1.156	14
		31.3		.0224		1.123		1.146		14
		29.7		.0214		1.134		1.155		14
		29.5		.0213		1.139		1.161		14
		28.6		.0206		1.138		1.159		14
		31.7		.0228		1.132		1.154		14
		30.9		.0223		1.132		1.155		14

3

Operation	Name	Date (GCT)	Time (GCT)	Location of Shot	Ground Zero Alt MSL (feet)	Burst Alt MSL (feet)	Height of Burst (feet)	Type of Burst	Air Pressure Ground Zero (mb)	Air Pressure Burst Height (mb)	Air… Gro… Zer…
Plumbob	Boltzman	28/5/57	1155	NTS	4235	4735	500	Tower	867	854	18.
	Franklin	2/6/57	1155	"	4025	4325	300	"	878	869	14.
	Lassen	5/6/57	1145	"	4230	4730	500	Balloon	872	855	23.
	Wilson	18/6/57	1145	"	4230	4730	500		882	864	17.
	Priscilla	24/6/57	1330	"	3076	3776	700	"	909.5	886.7	17.
	Hood	5/7/57	1140	"	4230	5730	1500	"	875	819	21.
	Diablo	15/7/57	1130	"	4469	4969	500	Tower	864	849	23.
	John	19/7/57	1400	"	4280	19,110	14,830	Rocket	870	424	21.
	Kepler	24/7/57	1150	"	4309	4809	500	Tower	865	854	21.
	Owens	25/7/57	1330	"	4215	4715	500	Balloon	871	854	20.
	Stokes	7/8/57	1225	"	4186	5686	1500	"	872	827	15.
	Shasta	18/8/57	1200	"	4387	4887	500	Tower	866	852	26.
	Doppler	23/8/57	1230	"	4186	5686	1500	Balloon	877	832	21.
	Franklin'	30/8/57	1240	"	4186	4936	750	"	868	844	11.
	Smoky	31/8/57	1230	"	4479	5179	700	Tower	856	844	14.
	Galileo	2/9/57	1240	"	4235	4735	500	"	878	862	15.
	Wheeler	6/9/57	1245	"	4215	4715	500	Balloon	876	861	20.
	LaPlace	8/9/57	1300	"	4186	4936	750	"	874	849	19.
	Fizeau	14/9/57	1645	"	3997	4497	500	Tower	880	865	25.
	Newton	16/9/57	1250	"	4186	5686	1500	Balloon	862	820	13.
	Whitney	23/9/57	1230	"	4486	4986	500	Tower	867	851	16.
	Charleston	28/9/57	1300	"	4215	5715	1500	Balloon	876	829	18.
	Morgan	7/10/57	1300	"	4215	4715	500	"	869	854	7.
Hardtack-I	Yucca	28/4/58	0240	Bikini ♦	0	85,000	85,000	Balloon	1010.5		30.
	Cactus	5/5/58	1815	Eniwetok	0	3	3	Surface	1010.5		27.
	Fir	11/5/58	1750	Bikini	0	9.88	9.88	Barge	1009.2		26.7
	Butternut	11/5/58	1815	Eniwetok	0	10.13	10.13	"	1008.1		27.
	Koa	12/5/58	1830	"	0	3	3	Surface	1010.2		27.
	Holly	20/5/58	1830	"	0	13.06	13.06	barge	1010.2		27.
	Nutmeg	21/5/58	2120	Bikini	0	12.11	12.11	"	1009.9		26.7
	Yellowwood	26/5/58	0200	Eniwetok	0	10.52	10.52	"	1011.9		30.
	Magnolia	26/5/58	1800	"	0	13.88	13.88	"	1010.5		26.7
	Tobacco	30/5/58	0215	"	0	9.06	9.06	"	1011.2		30.
	Sycamore	31/5/58	0300	Bikini	0	11.64	11.64	"	1009.4		27.
	Rose	2/6/58	1845	Eniwetok	0	15.43	15.43	"	1008.1		27.
	Maple	10/6/58	1730	Bikini	0	11.58	11.58	"	1010.7		27.
	Aspen	14/6/58	1730	"	0	10.82	10.82	"	1011.0		27.
	Walnut	14/6/58	1830	Eniwetok	0	7.21	7.21	"	1010.8		26.7
	Linden	18/6/58	0300	Bikini	0	8.25	8.25	"	1009.9		27.
	Redwood	27/6/58	1730	"	0	10.79	10.79	"	1010.1		27.
	Elder	27/6/58	1830	Eniwetok	0	9.17	9.17	"	1008.5		27.

♦ 60 miles west of Bikini
* data for Eniwetok

TABLE 1 (Cont.)

(* terms defined at end of Table

ght Burst et)	Type of Burst	Air Pressure Ground Zero (mb)	Air Pressure Burst Height (mb)	Air Temperature Ground Zero (°C)	Air Temperature Burst Height (°C)	Dew Point* Ground Zero (°C)	Dew Point* Burst Height (°C)	Relative Humidity* Ground Zero (%)	Relative Humidity* Burst Height (%)	Vapor Pressure* Ground Zero (mb)	Vapor Pressure* Burst Height (mb)	Vapor Density* Ground Zero (g/l)	Vapor Density* Burst Heigh (g/l)
0	Tower	987	854	18.5	21.3	4.5	3.4			8.42	7.79	.00626	.0097
0	"	878	869	14.8	21.2	3.5	6.4			7.85	9.61	.00591	.0070
0	Balloon	872	855	23.9	27.2	9.9	8.9			12.2	11.4	.00890	.0082
0	"	882	864	17.1	20.5	3.0	3.2			7.58	7.68	.00566	.0056
0	"	909.5	886.7	17.5	24.0	-0.6	-0.2			5.85	6.02	.00436	.0043
0	"	875	819	21.3	26.8	-3.4	-3.6			4.75	4.68	.00350	.0033
0	Tower	864	849	23.1	23.8	-0.8	-0.3			5.76	5.98	.00421	.0043
830	Rocket	870	424	21.8	-17.4	1.2				6.66		.00489	
0	Tower	865	854	21.0	21.0	-5.0	-2.7			4.21	5.01	.00310	.0036
0	Balloon	871	854	20.0	23.1	-3.6	-0.8			4.68	5.76	.00346	.0042
0		872	827	15.7	18.4	-5.8	-0.9			3.97	5.72	.00298	.0042
0	Tower	866	852	26.4	26.5	8.9	8.0			11.4	10.7	.00825	.0077
0	Balloon	877	832	21.4	22.0	13.9	10.4			15.9	12.6	.0117	.0092
0	"	868	844	11.0	14.3	-3.7	0.2			4.65	6.20	.00355	.0046
0	Tower	856	844	14.0	15.2	-3.6	-1.2			4.68	5.60	.00353	.00421
0	"	878	862	15.8	18.8	-1.5	-0.5			5.47	5.89	.00410	.00437
0	Balloon	876	861	20.0	23.8	-1.1	2.3			5.64	7.21	.00417	.0052
0	"	874	849	19.0	25.4	1.2	1.7			6.66	6.90	.00494	.00501
0	Tower	880	865	25.1	22.0	-1.5	-3.0			5.47	4.90	.00397	.0036
0	Balloon	862	820	13.2	17.9	-5.6	-5.3			4.03	4.12	.00305	.00307
0	Tower	867	851	16.1	17.0	-3.7	-3.7			4.65	4.65	.00348	.00347
0	Balloon	876	829	18.1	18.5	0.9	1.7			6.52	6.90	.00485	.00513
0	"	869	854	7.3	11.9	-5.9	-5.0			3.94	4.21	.00304	.00320
000	Balloon	1010.5		30.0		22.2				26.8		.0191	
3	Surface	1010.5		27.2		23.3				28.6		.0206	
9.88	Barge	1009.2		26.7		22.8				27.7		.0200	
0.13	"	1008.1		27.2		22.8				27.7		.0200	
3	Surface	1010.2		27.2		23.3				28.6		.0206	
3.06	Barge	1010.2		27.2		23.9				29.7		.0214	
2.11	"	1009.9		26.7		22.2				26.8		.0194	
0.52	"	1011.9		30.0		22.2				26.8		.0192	
3.88	"	1010.5		26.7		22.2				26.8		.0194	
7.06	"	1011.2		30.0		23.9				29.7		.0212	
1.64	"	1009.4		27.5		22.8				27.7		.0200	
5.43	"	1008.1		27.2		23.3				28.6		.0206	
1.58	"	1010.7		27.2		23.3				28.6		.0206	
0.82	"	1011.0		27.2		23.3				28.6		.0206	
7.21	"	1010.8		26.7		23.9				29.7		.0215	
3.25	"	1009.9		27.5		22.5				27.2		.0196	
0.79	"	1010.1		27.2		26.1				33.8		.0244	
0.17	"	1008.5		27.2		23.3				28.6		.0206	

2

(* terms defined at end of Table)

Relative Humidity* Ground Zero (%)	Relative Humidity* Burst Height (%)	Vapor Pressure* Ground Zero (mb)	Vapor Pressure* Burst Height (mb)	Vapor Density* Ground Zero (g/l)	Vapor Density* Burst Height (g/l)	Dry Air Density* Ground Zero (g/l)	Dry Air Density* Burst Height (g/l)	Wet Air Density* Ground Zero (g/l)	Wet Air Density* Burst Height (g/l)	References
		8.42	7.79	.00626	.00573	1.026	1.001	1.032	1.007	15
		7.85	9.61	.00591	.00707	1.053	1.017	1.059	1.024	15
		12.2	11.4	.00890	.00822	1.008	.978	1.017	.987	15
		7.58	7.68	.00566	.00567	1.050	1.016	1.055	1.022	15
		5.85	6.02	.00436	.00439	1.083	1.032	1.087	[illegible]	15
		4.75	4.68	.00350	.00338	1.030	.946	1.033	.949	15
		5.76	5.98	.00421	.00436	1.009	.989	1.013	.993	15
		6.66		.00489		1.020	.578	1.025	.578	15
		4.21	5.01	.00310	.00369	1.019	1.005	1.023	1.009	15
		4.68	5.76	.00346	.00421	1.030	.997	1.033	1.002	15
		3.97	5.72	.00298	.00425	1.047	.981	1.050	.986	15
		11.4	10.7	.00825	.00774	.994	.978	1.002	.986	15
		15.9	12.6	.0117	.00925	1.018	.967	1.030	.976	15
		4.65	6.20	.00355	.00467	1.058	1.015	1.062	1.020	15
		4.68	5.60	.00353	.00421	1.033	1.013	1.036	1.017	15
		5.47	5.89	.00410	.00437	1.052	1.022	1.056	1.026	15
		5.64	7.21	.00417	.00526	1.034	1.002	1.038	1.007	15
		6.66	6.90	.00494	.00501	1.034	.983	1.039	.988	15
		5.47	4.90	.00397	.00360	1.021	1.015	1.025	1.019	15
		4.03	4.12	.00305	.00307	1.044	.977	1.047	.980	15
		4.65	4.65	.00348	.00347	1.039	1.016	1.042	1.020	15
		6.52	6.90	.00485	.00513	1.040	.982	1.045	.987	15
		3.94	4.21	.00304	.00320	1.075	1.039	1.078	1.042	15
		26.8		.0191		1.130		1.150*		16
		28.6		.0206		1.139		1.160		16
		27.7		.0200		1.140		1.160		16
		27.7		.0200		1.137		1.157		16
		28.6		.0206		1.139		1.159		16
		29.7		.0214		1.137		1.159		16
		26.8		.0194		1.142		1.162		16
		26.8		.0192		1.132		1.151		16
		26.8		.0194		1.143		1.162		16
		29.7		.0212		1.128		1.149		16
		27.7		.0200		1.138		1.157		16
		28.6		.0206		1.136		1.157		16
		28.6		.0206		1.139		1.160		16
		28.6		.0206		1.139		1.149		16
		29.7		.0215		1.140		1.161		16
		27.2		.0196		1.139		1.158		16
		33.8		.0244		1.132		1.157		16
		28.6		.0206		1.137		1.157		16

Operation	Name	Date (GCT)	Time (GCT)	Location of Shot	Ground Zero Alt MSL (feet)	Burst Alt MSL (feet)	Height of Burst (feet)	Type of Burst	Air Pressure	
									Ground Zero (mb)	Burst Height (mb)
Hardtack-I (Cont.)	Oak	28/6/58	1930	Eniwetok	0	6.5	6.5	Barge	1008.5	
	Hickory	29/6/58	0000	Bikini	0	12.11	12.11	"	1009.3	
	Sequoia	1/7/58	1830	Eniwetok	0	6.5	6.5	"	1007.1	
	Cedar	2/7/58	1730	Bikini	0	10.84	10.84	"	1008.5	
	Dogwood	5/7/58	1830	Eniwetok	0	12.25	12.25	"	1008.8	
	Poplar	12/7/58	0330	Bikini	0	11.66	11.66	"	1011.8	
	Juniper	22/7/58	0420	"	0	12.11	12.11	"	1009.0	
	Oliver	22/7/58	2030	Eniwetok	0	8.0	8.0	"	1008.5	
	Pine	26/7/58	2030	"	0	8.0	8.0	"	1008.8	
	Teak	1/8/58	1050	JI*	0	250,000	250,000	Rocket		
	Orange	12/8/58	1030	JI*	0	141,000	141,000	"		
	Fig	18/8/58	1600	Eniwetok				Surface		
Hardtack-II	Eddy	19/9/58	1400	NTS	4186.5	4686.5	500	Balloon	875	858
	Mora	29/9/58	1405	"	4186.5	5686.5	1500	"	874	826
	Quay	10/10/58	1430	"	4248.6	4348.6	100	Tower	876	870
	Lea	13/10/58	1320	"	4186.5	5686.5	1500	Balloon	878	831
	Hamilton	15/10/58	1600	"	3082.3	3132.3	50	Tower		
	Dona Ana	16/10/58	1420	"	4186.5	4636.5	450	Balloon	380	862
	Rio Arriba	18/10/58	1425	"	4009.6	4082.1	72.5	Tower	879	878
	Socorro	22/10/58	1330	"	4186.5	5636.5	1450	Balloon	874	836
	Wrangell	22/10/58	1650	"	3076.7	4576.7	1500	"		863
	Rushmore	22/10/58	2340	"	4214.2	4714.2	500	"	873	857
	Sandford	26/10/58	1020	"	3076.7	4576.7	1500	"		864
	DeBaca	26/10/58	1600	"	4186.5	5686.5	1500	"	879	829
	Humbolt	29/10/58	1445	"	4028.7	4053.7	25	Tower	885	
	Santa Fe	30/10/58	0300	"	4186.5	5686.5	1500	Balloon	876	828
Sun Beam	Little-Feller II	7/7/62	1900	NTS	5129.2	5132.2	3	Tower	845	
	Johnny Boy	11/7/62	1645	"	5153.5	5151.5	~ -2	Sub Surf.	848	
	Small Boy	14/7/62	1830	"	3077.8	3087.8	10	Tower	906	
	Little-Feller I	17/7/62	1700	"	5193.6	5196.6	3	Rocket	844	
Dominic +	Adobe	25/4/62	1546	CI**	0					
	Aztec	27/4/62	1602	"	0					
	Arkansas	2/5/62	1802	"	0					
	Questa	4/5/62	1905	"	0					
	Frigate-Bird	6/5/62	2330	"	0					
	Yukon	8/5/62	1801	"	0					
	Mesilla	9/5/62	1701	"	0					

* Johnston Island
** Christmas Island
\+ No meteorlogical data available for Dominic

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TABLE 1 (Cont.)

(* terms defined at enc

t Alt t)	Height of Burst (feet)	Type of Burst	Air Pressure Ground Zero (mb)	Air Pressure Burst Height (mb)	Air Temperature Ground Zero (°C)	Air Temperature Burst Height (°C)	Dew Point* Ground Zero (°C)	Dew Point* Burst Height (°C)	Relative Humidity* Ground Zero (%)	Relative Humidity* Burst Height (%)	Vapor Pressure* Ground Zero (mb)	Vapor Pressure* Burst Height (mb)	Vapor Ground Zero (g/l)
.5	6.5	Barge	1008.5		26.7		24.4				30.6		.0221
.11	12.11	"	1009.3		27.8		27.2				36.1		.0260
.5	6.5	"	1007.1		27.2		23.9				29.7		.0214
.84	10.84	"	1008.5		27.2		24.4				30.6		.0221
.25	12.25	"	1008.8		27.2		25.0				31.7		.0229
.66	11.66	"	1011.8		30.0		24.4				30.6		.0219
.11	12.11	"	1009.0		27.8		25.0				31.7		.0228
.0	8.0	"	1008.5		26.7		24.4				30.6		.0221
.0	8.0	"	1008.8		27.2		25.0				31.7		.0229
00	250,000	Rocket											
00	141,000	"											
		Surface											
.5	500	Balloon	875	858	14.2	21.4	-7.9	-3.2			3.37	4.83	.00254
5	1500	"	874	826	11.8	17.3	6.5	5.0			9.67	8.72	.00735
6	100	Tower	876	870	15.3	15.6	-2.7	-2.9			5.01	4.93	.00376
5	1500	Balloon	878	831	13.4	18.3	-4.3	-1.0			4.44	5.68	.00336
3	50	Tower											
5	450	Balloon	380	862	13.7	19.9	-2.7	- .7			5.01	5.80	.00378
1	72.5	Tower	879	878	9.3	9.4	-10.3	-10.7			2.80	2.71	.00215
5	1450	Balloon	874	836	4.7	9.3	-14.7				1.96		.00153
7	1500	"		863		11.1							
2	500	"	873	857	17.8	16.3							
7	1500	"		864		9.4		5.7				9.15	.00701
5	1500	"	879	329	8.3	7.6	5.1	2.1			8.78	7.11	.00876
7	25	Tower	885		7.4		3.2				7.68		.00593
5	1500	Balloon	876	828	12.1	11.6	- 7.4	-11.3			3.51	2.58	.00267
2	3	Tower	845		26.5								
5	~ -2	Sub Surf.	848		24.3				12		3.64		.00265
3	10	Tower	906		35.0		4.0				8.13		.00771
5	3	Rocket	844		25.0		.2				6.20		.00449

(* terms defined at end of Table)

Relative Humidity* Ground Zero (%)	Relative Humidity* Burst Height (%)	Vapor Pressure* Ground Zero (mb)	Vapor Pressure* Burst Height (mb)	Vapor Density* Ground Zero (g/l)	Vapor Density* Burst Height (g/l)	Dry Air Density* Ground Zero (g/l)	Dry Air Density* Burst Height (g/l)	Wet Air Density* Ground Zero (g/l)	Wet Air Density* Burst Height (g/l)	References
		30.6		.0221		1.136		1.158		16
		36.1		.0260		1.127		1.153		16
		29.7		.0214		1.134		1.155		16
		30.6		.0221		1.134		1.156		16
		31.7		.0229		1.133		1.156		16
		30.6		.0219		1.128		1.149		16
		31.7		.0228		1.131		1.154		16
		30.6		.0221		1.136		1.158		16
		31.7		.0229		1.133		1.156		16
		3.37	4.83	.00254	.00248	1.057	1.011	1.059	1.013	17
		9.67	8.72	.00735	.00650	1.057	.980	1.064	.987	17
		5.01	4.93	.00376	.00370	1.052	1.044	1.056	1.047	17
		4.44	5.68	.00336	.00422	1.062	.987	1.065	.991	17
										17
		5.01	5.80	.00378	.00429	1.063	1.018	1.066	1.022	17
		2.80	2.71	.00215	[illegible]	1.081	1.079	1.083	1.081	17
		1.96		.00153		1.093		1.095		17
										17
										17
			9.15	.00701		1.054		1.061		17
		8.78	7.11	.00876	.00549	1.077	1.020	1.084	1.025	17
		7.68		.00593		1.089		1.095		17
		3.51	2.58	.00267	.00196	1.066	1.010	1.068	1.012	17
										18
12		3.64		.00265		.989		.992		18
		8.13		.00571		1.015		1.021		18
		6.20		.00449		.979		.983		18

3

TABLE 1 (Cont.)

Operation	Name	Date (GCT)	Time (GCT)	Location of Shot	Ground Zero Alt MSL (feet)	Burst Alt MSL (feet)
Dominic + (Cont.)	Muskegon	11/5/62	1537	CI**	0	
	Encino	12/5/62	1703	"	0	
	Swanee	14/5/62	1522	"	0	
	Chetco	19/5/62	1537	"	0	
	Tanana	25/5/62	1609	"	0	
	Nambe	27/5/62	1703	"	0	
	Alma	8/6/62	1703	"	0	
	Truckee	9/6/62	1537	"	0	
	Yeso	10/6/62	1601	"	0	
	Harlem	12/6/62	1537	"	0	
	Rinconada	15/6/62	1601	"	0	
	Dulce	17/6/62	1601	"	0	
	Petit	19/6/62	1501	"	0	
	Otowi	22/6/62	1601	"	0	
	Bighorn	27/6/62	1519	"	0	
	Bluestone	30/6/62	1521	"	0	
	Starfish	9/7/62	0900	JI*	0	400.09 KM
	Sunset	10/7/62	1633	CI**	0	
	Pamlico	11/7/62	1537	"	0	
	Androscoggin	2/10/62	1618	JI*	0	
	Bumping	6/10/62	1603	"	0	
	Chama	18/10/62	1601	"	0	
	Checkmate	20/10/62	0830	"	0	
	Bluegill	26/10/62	1000	"	0	
	Calamity	27/10/62	1546	"	0	
	Housatonic	30/10/62	1602	"	0	
	Kingfish	1/11/62	1210	"	0	
	Tightrope	4/11/62	0730	"	0	

* Johnston Island
** Christmas Island
\+ No meteorological data available for Dominic

DEFINITION OF TERMS

1. Dew Point is that temperature to which moist air must be cooled in order that it be water-saturated at the same initial pressure.

2. Relative Humidity of moist air is the ratio of the actual water vapor pressure to the saturated vapor pressure at the same temperature. (Saturated vapor pressure is the maximum possible vapor pressure of moist air at a given temperature.)

3. Vapor pressure is the pressure exerted by vapor in moist air and is equal to the total air pressure minus the dry air pressure.

4. Vapor density is the density of water (excluding dry air) in moist air.

5. Dry air density is the density of air (excluding water) in moist air.

6. Wet air density is the sum of vapor density and dry air density and is thus the density of moist air.

TABLE 2
Columnar Air Mass as a Function
of Geometric Altitude
For a Tropical Model Atmosphere

(1) Geometric Altitude (km)	(2) Model Air Density (g/1)	(3) Vertical Columnar Air Mass (g/cm^2)	(4) Remaining Columnar Air Mass (g/cm^2)	(1) Geometric Altitude (km)	(2) Model Air Density (g/1)	(3) Vertical Columnar Air Mass (g/cm^2)
0	1.16655	0.0	1.03790+3*	40	4.18106-3	1.03474+3
1	1.06443	[illegible]	9.86428+2	41	3.63279	1.03513
2	9.68878-1	[illegible]	8.94837	42	3.16106	1.03546
3	8.75708	[illegible]	7.32686	43	2.75339	1.03576
4	7.95068	[illegible]	6.49212	44	2.40137	1.03602
5	7.19873	[illegible]	5.73527	45	2.09671	1.03624
6	6.90142	[illegible]	5.05086	46	1.83298	1.03644
7	5.85483	[illegible]	4.43361	47	1.60416	1.03661
8	5.25844	[illegible]	3.87848	48	1.41124	1.03676
9	4.70827	[illegible]	3.38065	49	1.24627	1.03689
10	4.20269	7.44341	2.93558	50	1.10073	1.03701
11	3.73951	7.84034	2.53865	51	9.72185-4	1.03711
12	3.3157	8.19229	2.18670	52	8.61481	1.03721
13	2.92928	8.50414	1.87485	53	7.65886	1.03729
14	2.57790	8.77913	1.59986	54	6.80308	1.03736
15	2.25987	9.02066	1.35833	55	6.03762	1.03742
16	1.97234	9.23193	1.14706	56	5.35416	1.03748
17	1.67566	9.41393	9.65061+1	57	4.74377	1.03753
18	1.38841	9.56636	8.12627	58	4.19912	1.03758
19	1.14482	9.69235	6.86639	59	3.71353	1.03761
20	9.51540-2	9.79687	5.82119	60	3.28711	1.03765
21	7.93821	9.88390	4.95089	61	2.91711	1.03768
22	6.64484	9.95662	4.22365	62	2.58481	1.03771
23	5.61852	1.00178+3	3.61192	63	2.28621	1.03773
24	4.76296	1.00696	3.09402	64	2.01883	1.03775
25	4.04495	1.01135	2.65460	65	1.77976	1.03777
26	3.44184	1.01509	2.28110	66	1.56592	1.03779
27	2.93275	1.01827	1.96314	67	1.37534	1.03780
28	2.50193	1.02098	1.69802	68	1.20576	1.03782
29	2.13835	1.02329	1.46048	69	1.05483	1.03783
30	1.83099	1.02527	1.26843	70	9.21004-5	1.03784
31	1.56940	1.02697	1.09277	71	8.02445	1.03785
32	1.34739	1.02843	9.47211+0	72	6.97712	1.03785
33	1.15839	1.02968	8.22160	73	6.05184	1.03786
34	9.97425-3	1.03075	7.14570	74	5.23773	1.03787
35	8.59978	1.03168	6.21869	75	4.52286	1.03787
36	7.42560	1.03248	5.41886	76	3.89581	1.03788
37	6.41909	1.03317	4.72785	77	3.34702	1.03788
38	5.55687	1.03377	4.13008	78	2.85869	1.03788
39	4.81718	1.03429	3.61226	79	2.45048	1.03788

|

BLE 2
r Mass as a Function
metric Altitude
al Model Atmosphere

(3) Vertical Columnar Air Mass (g/cm^2)	(4) Remaining Columnar Air Mass (g/cm^2)
1.03474+3	3.16310+0
1.03513	2.77305
1.03546	2.43390
1.03576	2.13885
1.03602	1.88131
1.03624	1.65675
1.03644	1.46056
1.03661	1.28896
1.03676	1.13840
1.03689	1.00569
1.03701	8.88493-1
1.03711	7.84980
1.03721	6.93408
1.03729	6.12133
1.03736	5.39908
1.03742	4.75781
1.03748	4.18890
1.03753	3.38462
1.03758	3.23803
1.03761	2.84290
1.03765	2.49330
1.03768	2.18346
1.03771	1.90869
1.03773	1.66545
1.03775	1.45047
1.03777	1.26080
1.03779	1.09374
1.03780	9.46888-2
1.03782	8.18013
1.03783	7.05152
1.03784	6.06512
1.03785	5.20475
1.03785	4.45590
1.03786	3.80554
1.03787	3.24205
1.03787	2.75489
1.03788	2.33474
1.03788	1.97329
1.03788	1.66364
1.03788	1.39871

(1) Geometric Altitude (km)	(2) Model Air Density (g/1)	(3) Vertical Columnar Air Mass (g/cm^2)	(4) Remaining Columnar Air Mass (g/cm^2)
80	2.08818-5	1.03789+3	1.17226-2
81	1.74940	1.03789	9.80879-3
82	1.46075	1.03789	8.20805
83	1.21973	1.03789	6.87143
84	1.01847	1.03789	5.75535
85	8.50423-6	1.03789	4.82343
86	7.10235	1.03789	4.04520
87	5.93156	1.03790	3.39526
88	4.95377	1.03790	2.85246
89	4.13793	1.03790	2.39910
90	3.45646	1.03790**	2.02040

Note: +2, -1 etc. denote powers of 10. Succeeding entries have same exponent until a new exponent is noted.

*1037.898876000 **1037.896855597

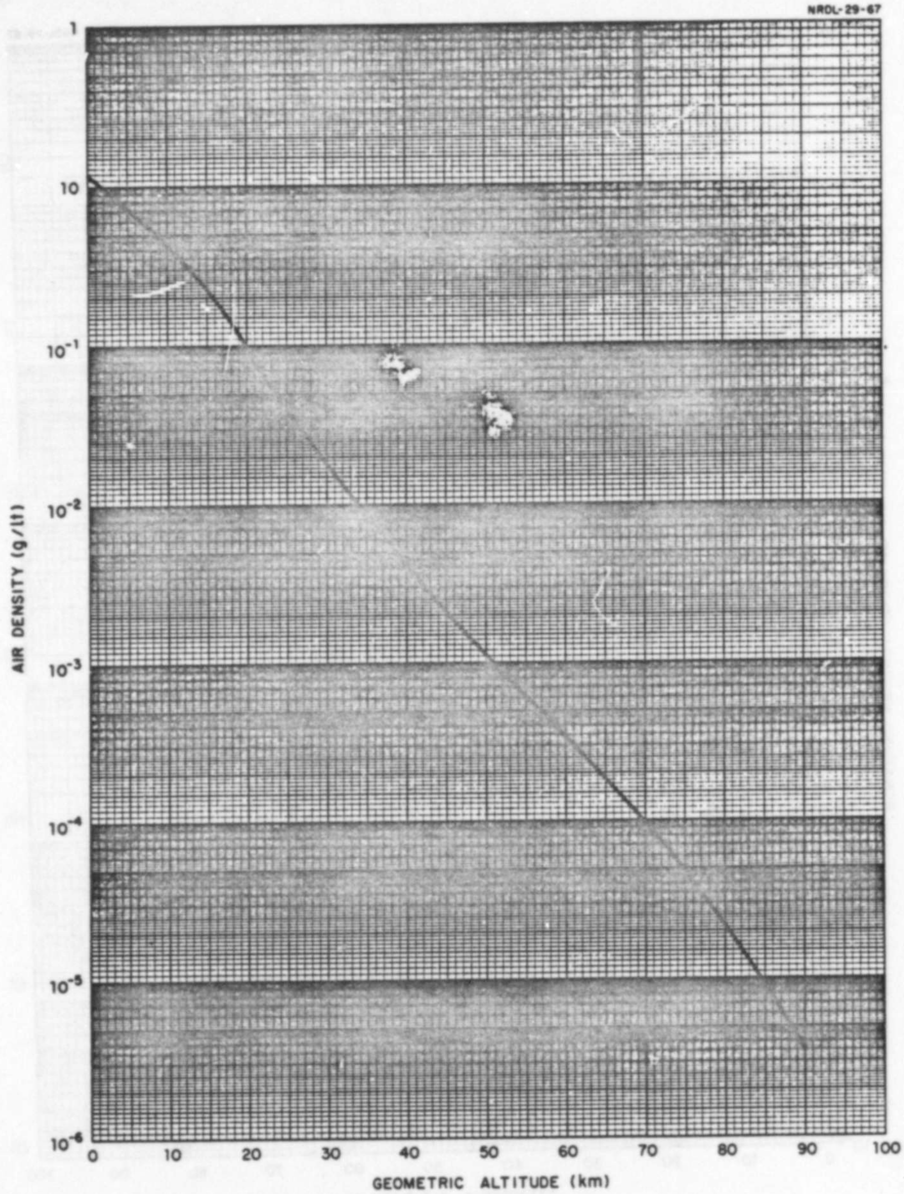

Fig. 1 Air Density vs Geometric Altitude

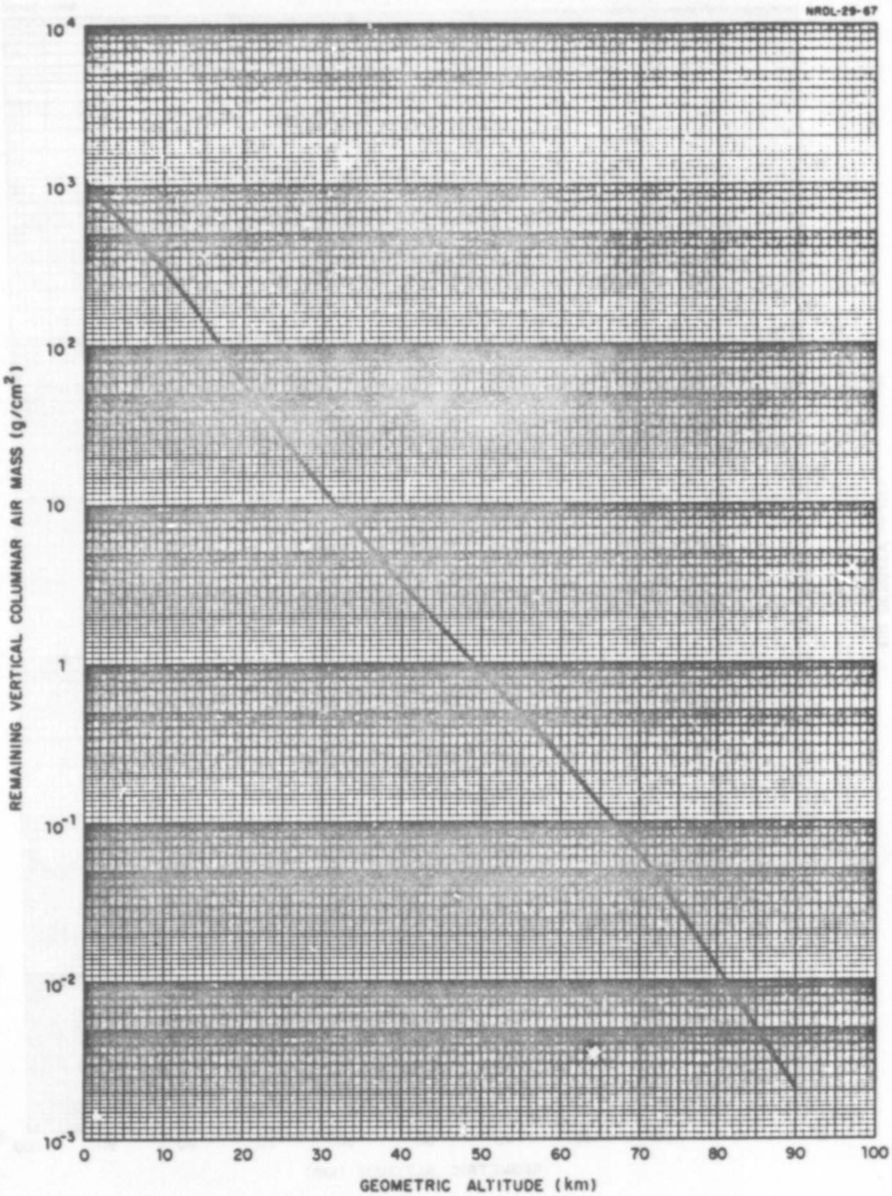

Fig. 2 Remaining Vertical Columnar Air Mass vs Altitude

Naval Radiological Defense Laboratory
USNRDL-TR-67-20
AIR DENSITIES FOR ATMOSPHERIC NUCLEAR TESTS AND COLUMNAR AIR MASS DATA, by T. A. Alexander
2 February 1967 32 p. tables illus.
22 refs. UNCLASSIFIED

A tabulation is presented of ground-zero and burst altitudes and associated dry-air and water-vapor density data for U. S. atmospheric nuclear tests. Also presented are density data for a tropical (15°N) atmosphere up to 90 kilometers. A method for computing columnar air mass between two points at different altitudes for the Pacific Proving Ground area is presented. This method can be (over)

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2. Nuclear explosions
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